

**UNITED STATES PATENT  
APPLICATION  
FOR GRANT OF LETTERS PATENT**

**Stephen Bennett Elliott  
INVENTOR**

**Method and System Providing A  
Fundamental Musical Interval for Heart  
Rate Variability Synchronization**

### Related Patent Filings:

Method and System for Consciously Synchronizing the Breathing Cycle with the Natural Heart Rate Cycle (10/699,025), Method and System for Synchronizing the Heart Rate Variability Cycle With The Breathing Cycle (February 19, 2004), Method of Presenting Audible and Visual Cues for Synchronizing the Breathing Cycle With An External Timing Reference for Purposes of Synchronizing The Heart Rate Variability Cycle With The Breathing Cycle (March 15, 2004)

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### Field of the Invention

The present invention relates to the field of human physiology, and in particular to a method and system for allowing a human subject to consciously control physiological processes, more particularly, it allows a human subject to achieve synchronization of the natural heart rate variability cycle with the breathing cycle via conscious synchronization of the breathing cycle with an audible timing reference, and more particularly to the creation of a musical standard by which the audible timing reference may be incorporated into musical composition.

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### Background of the Invention

The human heart is known to have its own nervous system and its own natural tendency toward rhythm. For purposes of this invention, there are two primary aspects to this rhythm, the heartbeat rate, and the rate at which the heartbeat rate changes otherwise known as heart rate variability. Heartbeat rate is usually specified in absolute number of heartbeats occurring during a specified period. Heartbeat rate variability, otherwise know as heart rate variability is the change in heartbeat rate as occurs during a specified period. Henceforth, heartbeat rate variability will be referred to as heart rate variability.

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While the heart has its own tendency toward rhythm, it is closely coupled to breathing. The relationship is such that as inhalation occurs, the heartbeat rate tends to increase and as exhalation occurs, the heartbeat rate tends to decrease. It is important to note that while the heartbeat rate and breathing rate influence each other, the relationship is a plesiochronous one, that is,

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they are independent rhythms that strongly influence but do not directly control each other.

It is generally recognized that heart rate variability is an indicator of

5 physiological and emotional state, that is, irregular incoherent heart rate variability indicates a condition of physiological/psychological stress.

Alternatively, a highly regular coherent heart rate variability is indicative of a condition of physiological/psychological harmony.

10 Accordingly, it is highly desirable to achieve and maintain a highly coherent heart rate variability as life circumstances permit. This having been said, with proper training and the application of the present invention, it is possible for a human subject to rapidly achieve the desired state of high coherence of heart rate variability and to reinforce that coherence on an ongoing basis.

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The present invention takes advantage of the relationship between the breathing cycle and the natural heart rate variability cycle to bring heart rate variability to the desired state of coherence and the human subject to the resultant state of physiological and emotional harmony. It accomplishes this

20 via synchronization of the heart rate variability cycle with the breathing cycle. More specifically, it accomplishes this by integrating audible cues in the form of recurring identifiable musical sequences with a fundamental periodicity of 5.88 seconds into musical composition. When a musical composition

according to the preferred embodiment of the present invention is played, the

25 listener(s) or singer(s) consciously synchronizes their breathing cycle to the recurring musical pattern, thereby synchronizing their heart rate variability cycle with their breathing cycle.

### Summary of the Invention

30 As previously described, a relationship exists between the heartbeat rate specified in terms of heart rate variability, and the breathing cycle. While the heart has its own tendency toward a natural variable rhythm, there is a strong correlation with breathing according to this specific relationship: as inhalation occurs, there is a tendency for the heartbeat rate to increase, as exhalation

occurs, there is a tendency for the heartbeat rate to decrease. In a relaxed or semi-active human subject, the effect of the breathing cycle on the heart rate variability cycle is extremely strong. In fact, the heart rate variability cycle will synchronize with the breathing cycle if the breathing cycle is highly attuned to the periodicity of the natural heart rate variability cycle. The nominal period of the typical human heart rate variability cycle is 11.76 seconds. Therefore, if the period of the breathing cycle is timed to 11.76 seconds, the heart rate variability cycle will synchronize with it, bringing the natural heart rate variability cycle into phase synchrony with the breathing cycle and thereby bringing the subject's heart rate variability cycle into the desired state of coherence.

The present invention accomplishes this by presenting the human subject with musical cues to which the breathing cycle is consciously synchronized. These musical cues are identifiable recurring sequences with a fundamental periodicity of 11.76 seconds divided by 2, or 5.88 seconds, representing the 50% of the 11.76 second heart rate variability cycle and corresponding to 50% of the breathing cycle of like period, that is, the period of inhalation or exhalation.

When the breathing is consciously synchronized to these musical cues, the heart rate variability cycle will synchronize with the breathing cycle and remain synchronized as long as the breathing cycle remains aligned with the musical cues. In this way, the human subject can remain in the desired state of coherence of heart rate variability for extended periods of time. Ultimately, this builds familiarity with the desired psycho-physiological condition such that synchronization with the external reference occurs subliminally and with continued practice, the state can be realized at will with or without the external timing reference signal.

For purposes of the present invention, we can consider the cycles of heart rate variability, the periodicity of increasing and decreasing of heartbeat rate, and the breathing cycle, the periodicity of inhalation and exhalation, to be two independent cycles. The relative synchronization of these cycles can vary

between 0 and 180 degrees. When these cycles are completely out of phase, heart rate variability is maximally incoherent, when these cycles are completely in phase heart rate variability is maximally coherent.

- 5 The fundamental challenge of integrating a 5.88 second interval into music is that the present state of the art standard for musical interval does not accommodate a 5.88 second periodicity. Musical interval is a function of tempo. Tempo according to the present state of the art is defined in terms of beats per minute. This standard was instantiated at the time of Johan
- 10 Maelzel's improvement on the basic metronome circa 1816. It is Maelzel's Metronome that is the lasting standard for musical tempo today. Consequently, the most basic embodiment of the present invention is the redefinition of musical tempo to incorporate the fundamental 5.88 second interval. A second embodiment of the present invention is the incorporation of
- 15 this fundamental interval in to the metronome. A third embodiment of the present invention is the incorporation of the fundamental 5.88 second interval into the musical synthesizer for purposes of producing both a reference tempo and music in accordance with the reference tempo.

## 20 Brief Description of the Drawing Figures

The accompanying drawing figures incorporated in and forming a part of this specification illustrate several aspects of the invention, and together with the description serve to explain the principles of the invention.

- FIGURE 1 presents a table comparing musical tempo according to the
- 25 present state of the art with the new musical tempo according to the preferred embodiment of the present invention.

FIGURE 2 presents an example of musical composition wherein the present invention is applied.

- FIGURE 3 presents a second example of musical composition wherein the
- 30 present invention is applied.

FIGURE 4 presents a logical metronome topology.

FIGURE 5 presents a logical synthesizer topology.

FIGURE 6 presents a logical mechanical metronome topology.

FIGURE 7 presents a logical electronic metronome topology.

FIGURE 8 presents a logical electronic hardware-optimized metronome or synthesizer.

FIGURE 9 presents a logical electronic software-optimized metronome or synthesizer.

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#### Detailed Description of the Preferred Embodiments

The present invention provides a method and system by which a 5.88 second interval may be incorporated into musical composition for the purposes of providing listeners and singers with musical breathing cues with which the breathing cycle is to be consciously synchronized for purposes of synchronizing the heart rate variability cycle with the breathing cycle.

A primary embodiment of the present invention is a standard for tempo that accommodates the fundamental interval of 5.88 seconds. With this tempo standard, musical composition can be created that incorporates recurring melodic sequences for purposes of synchronization of the breathing cycle and listening enjoyment. FIGURE 1 presents a table comparing tempo according to the present state of the art with tempo according to the preferred embodiment of the present invention. The left section of FIGURE 1 presents musical tempo according to the present state of the art in beats per minute as defined by Maelzel's Metronome. For purposes of comparison, column 102 presents beats per 60 seconds from 1 beat in 60 seconds to 214 beats in 60 seconds. It is important to note that Maelzel's Metronome addresses the range 40 beats per minute to 208 beats per minute. Columns 103 and 104 present corresponding interval in seconds and beats per second, respectively. The right section of FIGURE 1 presents musical tempo as defined by the preferred embodiment of the present invention incorporating the fundamental 5.88 second interval. As in the left aspect of FIGURE 1, columns 108, 109, and 110 present beats per 60 seconds, interval in seconds, and beats per second, respectively. Column 111 divides the fundamental 5.88 second period by the interval in seconds.

For tempo to accommodate the 5.88 second period the interval **109** must be evenly divisible into 5.88 seconds. These tempos **112, 113, 114, – 132**, are identified at every point where they occur between the range of 1 beat in 60 seconds to 214 beats in 60 seconds. The preferred embodiment of the

5 present invention requires the specification of 17 new tempos **112, 113, 114, 115, 117, 118, 119, 120, 122, 123, 124, 125, 127, 128, 129, 130, 132**, and the identification of 4 existing tempos **116, 121, 126, and 131** that are evenly divisible into 5.88 seconds, the latter 4 already existing in the present state of the art scheme but heretofore unidentified in terms of their relevance to heart

10 rate variability synchronization. These tempos having been specified per the present invention, musical composition deliberately employing these tempos for purposes of breathing cycle synchronization leading to heart rate variability synchronization may now occur.

15 For purposes of example, FIGURE 2 presents an existing musical composition, Silent Night, wherein the present invention is applied. **201** depicts the basic 5.88 second interval occurring sequentially in time. **202** demonstrates the musical staff with 4 bars designated **203, 204, 205, 206**, delineating the 5.88 second interval. Bars are delineated by chime **208, 209,**

20 **210, 211**, the chime signaling the exact moment when the breathing cycle is to change phase from inhalation to exhalation or from exhalation to inhalation. The chime is used only as an example of this musical signal. Similarly, the end of the bar may be signaled with any identifiable musical event including a drum beat, a bass note, etc. Within each bar, a melodic segment occurs. In

25 the case of song, the words of the song are timed such that inhalation and exhalation occur naturally within the bar. For example, in the beginning stanza, Si – lent night, “night” ends slightly before the end of the bar to allow a singer to pause for a moment between the end of “night” and the beginning of inhalation occurring at the end of the bar. This timing is indicated by **212,**

30 **213, 214, and 215**. This musical method lends itself to different singers **216, 217** singing alternating stanzas such that singer 1 **216** is singing while singer 2 **217** inhales. Singer 2 **217** sings as signer 1 **216** inhales and so forth. It should be clear that Silent Night is used merely for purposes of providing an

example of a broad method that is generally applicable to all music and vocal accompaniment.

Yet another example of the preferred embodiment of the present invention is depicted in FIGURE 3, 302 wherein a recurring melodic sequence 305, 306 is played within each 5.88 second bar 303, 304. In this example, a singer or listener changes their breathing phase in between the end of one melodic sequence and the beginning of the next. This continues on a recurring basis throughout the length of the composition. This melodic sequence may occur in either the background, such as a bass, or it may occur in the foreground as the lead harmony. This does not matter as long as the recurring sequence is easily discernable to the human ear such that the singer(s) or listener(s) may consciously synchronize their breathing with it. A second example is identified by 307 wherein melodic sequences signaling inhalation 308 are and exhalation 309 are distinctive.

A second fundamental embodiment of the present invention is a tempo generator or metronome capable of supporting the fundamental 5.88 second interval. The tempo generating function may be provided either in the form of a discrete metronome FIGURE 4, that is, a functional element exclusively designed to generate tempo to which musical instruments are played in time, or it may be an integral part of a synthesizer FIGURE 5 in which case it not only generates the tempo for purposes of musical timing but also produces an audio output that is an integral part of the music being played and potentially recorded. In either case, the tempo generator must be capable of generating timings that are in keeping with the 5.88 second interval. These timings were discussed relative to FIGURE 1 will now be presented more exactly. Either a metronome, or a synthesizer must be capable of generating these specific beats expressed in terms of beats per minute: 10.2 112, 20.4 113, 30.6 114, 40.8 115, 51.0 116, 61.2 117, 71.4 118, 81.6 119, 91.8 120, 102.0 121, 112.2 122, 122.4 123, 132.6 124, 142.8 125, 153.0 126, 163.2 127, 173.4 128, 183.6 129, 193.8 130, 204.0 131, and 214.2 132. Again, it should be noted that this preferred embodiment of the present invention both spans the range of Maelzel's Metronome and also extends the range of beats of interest



beyond that of Maelzel's Metronome by providing a lowest order beat of 10.2 beats per minute **112** and a highest order beat of 214.2 beats per minute **132**.

Referring to FIGURES 6 and 7, metronomes of both the mechanical and  
5 electronic variety are intended within the scope of the present invention. The mechanical instance of which is seen as an improvement to Maelzel's Metronome in which the mechanical programmability of specific tempos **112 - 132** is provided. These tempos may be provided in addition to present tempos or separately. This is to say that an instance of a mechanical  
10 metronome may be provided that provides only the tempos according the preferred embodiment of the present invention. The same is true of electronic metronomes, the programmability of which is provided electronically. Both forms of metronome provide some form of control system **601, 701**, be it mechanical or electronic, some form of user interface **602, 702**, be it  
15 mechanical or electronic, and some form of output interface **603, 703**, be it mechanical or electronic. Control, user interface, and output interface aspects as they relate to the production of the tempos according to the preferred embodiment of the present invention are assumed within the scope of the present disclosure and accompanying claims.

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Referring now to FIGURES 8 and 9, both hardware-optimized and software-optimized topologies of electronic metronomes and synthesizers are assumed within the scope of the present invention. FIGURE 8 presents the basic topology and partitioning of a hardware-optimized metronome or synthesizer  
25 consisting of a control system **801** comprising hardware timing and sequencer **802** and memory **803**, a user interface **804**, and an output interface **805**. This topology assumes that tempos and related audio signals are generated on the basis of hardware timing and sequencer **802** which may take the form of an integrated circuit, a programmable logic array, or other hardware instantiation.  
30 Audio samples or the mathematical equivalent thereof may be stored in memory **803** and accessed according to a hardware oriented timing and sequencing algorithm as determined by the program selection via user interface **804**. The resultant audio signal in either analog or digital form and consisting of a tempo of the desired beat and musical characteristics is output

via output interface 805. FIGURE 9 presents a processor based metronome or synthesizer topology. It consists principally of a control system 901 consisting of a microprocessor, memory, and software. Software programs residing in memory 902 and under the control of the user interface 904, when  
 5 executed by the microprocessor, generate the analog or digital audio signal which is output via output interface 905. The major classes of electronic metronomes and synthesizers are hardware-optimized and software-optimized varieties. It is understood that variations may exist wherein both hardware-optimized and software-optimized methods are employed  
 10 individually or in combination to varying degree. Those skilled in the art will understand the concepts of the present invention and will recognize applications of these concepts not particularly addressed herein. It should be understood that these concepts and applications fall within the scope of the disclosure and the accompanying claims.

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An instructive method is also specified for use with the present invention.

Instructive Method:

- 20 1. Listening participants are instructed to assume a comfortable posture.
2. Listening participants are instructed to relax and listen to the music to identify the 5.88 second interval.
3. The 5.88 second interval is demonstrated to the listening audience such that they are able to identify it and discern it as the music is being played.
- 25 4. Individual participants are instructed to inhale and exhale on alternating 5.88 second intervals.
5. Participating groups are instructed to inhale and exhale in such a way as to synchronize their inhalation on certain 5.88 second intervals and synchronization their exhalation on alternating 5.88 second intervals.
- 30 6. Listening participants are instructed to continue inhaling and exhaling on alternating 5.88 second intervals for the duration of the music.
7. Singing participants are instructed to sing on alternating 5.88 second intervals such that they are able to sing during one interval and inhale on the next interval.

8. Where there is a song that must be song with continuity, multiple singers are instructed to sing on alternating stanzas such that as the first singer(s) sings the second singer(s) inhales and as the second singer(s) sings the first singer in hales.

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